SECTION 3
SITE SELECTION

Selecting sites for Caltrans stormwater monitoring depends primarily on the program objectives, permit requirements, and parameters of interest. However, once these criteria have been used to establish the number and type(s) of monitoring sites, consideration of the following items will help ensure selection of the most appropriate monitoring locations:

KEY TOPICS

- ➤ **Representativeness**
- ➤ **Personnel Safety**
- ➤ **Site Access**
- ➤ **Equipment Security**
- ➤ **Flow Measurement Capability**
- ➤ **Electrical Power and Telephone**
- ➤ **Non-Caltrans Sources**
- ➤ **BMP Effectiveness**
- ➤ **Site Visit**

Each of these considerations is discussed in detail in this section. If program goals include evaluation of BMP effectiveness, additional considerations may be needed to select appropriate sampling locations. Such additional considerations are outlined in the latter part of this section.

➤ REPRESENTATIVENESS

Types of sampling sites specified for Caltrans monitoring may include highway sites (freeways, expressways and/or conventional highways), maintenance yards, park-and-ride lots, or construction sites. It is important to select specific monitoring sites that are representative of typical Caltrans operations for these site types. The following discussions provide guidance on site characteristics to consider when selecting representative monitoring sites.

Highway Sites

Several considerations must be used in the selection of appropriate highway stormwater sampling sites, including permit requirements, traffic volume, grade, and location relative

to other land uses. Sampling may be conducted at various locations in Caltrans Districts, such as ramps, 2-lane highways, multiple lane freeways, etc. Although certain monitoring areas may be specified by a permit, factors such as traffic volume, grade, and surrounding land uses should still be considered when selecting the exact location within the specified area. The following considerations will help to ensure selection of sites that are representative of highway runoff:

✔ Permit Requirements

Selection of monitoring sites may be influenced by specific permit requirements. All stormwater and non-stormwater discharges from Caltrans highways and highway-related properties, facilities, and activities are regulated under a National Pollutant Discharge Elimination System (NPDES) permit. Sites that are selected in fulfillment of a permit provision may require the approval of the permitting agency (check specific permit language for any such requirement)).

✔ Traffic Volume

The selected sampling site should be located where the traffic volume is comparable to the average range of daily traffic volumes in the respective Caltrans District for the type of highway being studied. Selecting sites with typical traffic volumes may help ensure that the sites are representative of normal

conditions. Check with the local Caltrans District office for typical ADTs, as well as the annual compilation of highway traffic volumes published by Caltrans (Caltrans, 1999e).

✔ Uniform Flow

Sampling sites should be located where runoff flows are relatively well mixed, yet tend to be relatively "stable" or "uniform". To better approach uniform flows, avoid steep slopes (i.e., select sites with pipe slope less than 2% to achieve uniform flows in the subcritical range), junctions, grade changes, and areas of irregular channel shape due to breaks, repairs, roots, debris, etc. Sites should be located where the channel or storm drain is soundly constructed.

✔ Erosion Potential

Avoid areas where the potential for erosion is high, such as areas where land has recently been disturbed by construction or other activities, areas with excessively steep slopes, or cut and fill areas where the land surface has not been fully stabilized.

✔ Surrounding Land Uses

Select sites that are not likely to be significantly affected by surrounding land uses via atmospheric deposition or flows from non-Caltrans areas. For example, do not select sites in close proximity to agricultural fields that may be sprayed with pesticides, or industrial sites that may contribute airborne constituents, when deposition from those sites may affect on-site concentrations of monitoring project constituents.

✔ Backwater or Tidal Influences

Select sampling sites where the runoff will be free-flowing (gravity flow). Avoid areas likely to be affected by backwater and tidal conditions (illustrated in Figure 3-1), as these factors can complicate the reliable measurement of flow and the interpretation of data.

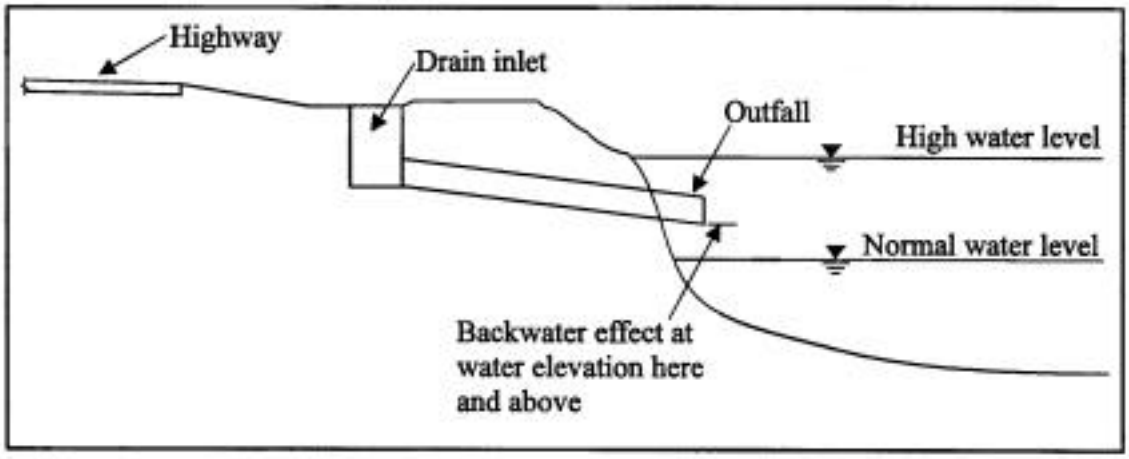

Figure 3-1. Backwater Influence

✔ High Groundwater Table

A high groundwater table may influence stormwater runoff if groundwater reaches the surface and mixes with stormwater runoff; therefore, avoid sites where there is a potential for this to occur.

✔ Illegal Discharges/Illicit Connections

An inspection of the site should include identification of any signs of illegal discharges, which generally include illegal discharge/dumping of wastes (e.g., used oil and other automotive fluids, trash and debris, etc.) and illicit connections of sanitary sewer lines to the storm drainage system. Selected sites should be free of illegal discharges and illicit connections.

To adequately assess illegal discharges and illicit connections, sites should be visited during dry weather to observe any non-stormwater runoff. The following on-site observations should be made to identify illegal discharges and illicit connections:

- ✔ Presence of debris, or rubbish piles on roadway shoulders, at turnouts, in open channels or other areas of the potential monitoring site. Solid waste dumping often occurs on roadways with light traffic loads or in areas not easily visible from the traveled way. Approach containers, such as bottles or barrels, with caution as they may contain hazardous liquids or solids.
- ✔ Visible signs of staining or unusual colors to the pavement or surrounding adjacent soils.
- ✔ Pungent odors coming from the drainage system.
- ✔ Discoloration or oily substances in the water or stains and residues detained within ditches, channels or drain boxes.
- ✔ Abnormal water flow during dry weather, including irrigation tail waters.
- ✔ Unusual flows in subdrain systems used for dewatering.
- ✔ Excessive sediment deposits, particularly adjacent or near active off-site construction projects.

If potential sites are in rural areas, also check for non-standard junction structures and broken concrete, disturbed soil, removed vegetation, or other disturbances at or near junction structures.

All observations should be documented for potential future use. If an illegal discharge or illicit connection is observed on a Caltrans right-of-way, the Caltrans stormwater coordinator should be notified. If the nature of an observed discharge is unknown or suspected of being a hazardous substance, no further investigation should be conducted and the incident reported to the Caltrans stormwater coordinator.

- ✔ Significant Transitions

Generally, when considering representative highway sampling sites, it is desirable to select areas that are unlikely to undergo significant transition in the near future. This is to prevent the intrusion of contaminants from construction activities, or other alterations to the monitored area that may cause changes in the quality of the runoff (i.e., cause the quality of the runoff to be atypical of the type of site being monitored). Check with the local Caltrans District office as to whether construction or other significant activities are planned in the area.

Figure 3-2 illustrates a typical highway sampling site in southern California.

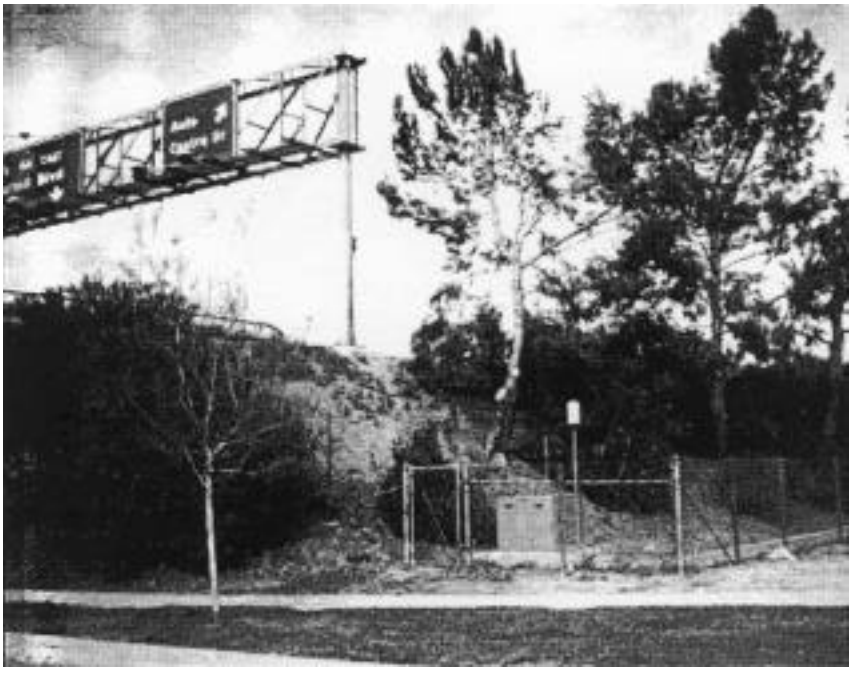

Figure 3-2. Representative Highway Sampling Site

Maintenance Yards

Locations where highway maintenance vehicles and equipment are stored and serviced may be selected as stormwater monitoring sites. Maintenance activities, including vehicle and equipment cleaning, fueling, and repair, may all contribute constituents of concern to stormwater runoff. Constituents that may be associated with these activities are discussed in ***Section 4.***

Effective monitoring of maintenance yards requires selection of sampling sites that adequately represent typical runoff from the site, prior to mixing with off-site sources. Select sampling sites that have the following characteristics:

- ✔ Runoff from the facility has combined to form a definable runoff stream of adequate depth to sample (generally at least _" depth).
- ✔ The runoff stream fairly well represents the full range of activities at the facility.
- ✔ On-site runoff has not combined with runoff from off-site (non-Caltrans) sources.

- ✔ Adequate grade or a drop-off exists (e.g., into a drain inlet) to enable collection of runoff samples by placing a sample bottle in the runoff stream (if manual sampling is planned).

Refer also to other conditions described above for selection of highway sampling locations.

Park-and-Ride Lots

Monitoring at park-and-ride lots may be included in Caltrans stormwater monitoring efforts. Effective monitoring of park-and-ride lots requires selection of sampling locations that adequately represent typical runoff from the site prior to mixing with off-site sources. Select sampling sites that have the following characteristics:

- ✔ Runoff from the area has combined to form a definable runoff stream of adequate depth to sample.
- ✔ On-site runoff has not combined with runoff from off-site (non-Caltrans) sources.
- ✔ Illicit connections are not present (refer to highway site section, above).
- ✔ Trash receptacles are provided and the area is routinely checked for trash and debris (including illegal dumping).

Refer also to other conditions described above for selection of highway sampling locations.

Construction Sites

Monitoring of highway construction sites may be required as part of legal or regulatory monitoring requirements for Caltrans Districts. Highway construction activities may contribute to increased concentrations of certain constituents (***Section 4***).

Effective monitoring of construction sites requires selection of sampling locations that adequately represent typical runoff from the site prior to mixing with off-site sources. Select sampling sites that have the following characteristics:

- ✔ Sampling site should be relatively fixed and stable (not subject to significant modification during construction).
- ✔ Sampling site should be in an active area of construction activity.
- ✔ Sampling location should not be influenced significantly by construction equipment exhaust.

- ✔ Sampling site should be located where runoff leaves the construction site, and where runoff from the site has combined to form a definable runoff stream of adequate depth to sample.

Refer also to other conditions described above for highway runoff and maintenance yards.

➤ PERSONNEL SAFETY

It is essential to ensure monitoring crew safety from such hazards as traffic, explosive or toxic gases, possible injury due to poor footing in slippery conditions, and hazards posed by poor visibility or other challenging conditions during adverse weather, especially at night. Figures 3-3 and 3-4 illustrate monitoring locations that expose sampling personnel to potential traffic hazards.

To help avoid hazards, personnel should be physically capable of performing all tasks required for sample collection and be familiar with the program's Health and Safety Plan. The Health and Safety Plan must be developed prior to the initiation of any sample collection activities and should include information on at least the following: hazard evaluation (e.g. chemical, physical, etc.), contingency plan, personal protective equipment, and emergency information. The requirements of the Health and Safety Plan are discussed in more detail in ***Section 6***.

Information regarding personnel safety during sample collection is provided in ***Section 10***.

Figure 3-3. Avoid Sites Adjacent to Freeway Travel Lanes

Figure 3-4. Avoid Sites that Require Traffic Diversion
(Source:Water Environment Federation, 1993)

➤ SITE ACCESS

Ease of vehicle and personnel access to the monitoring sites for equipment installation and sample collection activities should be assured for the full range of weather conditions that may be encountered. Safe access must be confirmed, especially during wet-weather conditions. For example, ensure that the access point and available parking are at a safe distance from traffic, that any roads to the sampling location are adequate and reliable (e.g., limited potential to be muddy or flooded during wet weather), and that access does not require crossing private property. Check with local agencies as to whether any permits will be required to gain legal access to the sites. Figure 3-5 illustrates an inappropriate sampling location due to poor access.

For stormwater outfall monitoring sites, access into the drainage line/outfall for the flow measuring and sample collection equipment must be feasible and practical. Where practical, access to monitoring sites and equipment should be possible without confined space apparatus or exposure to fast moving traffic, for ease of servicing.

Figure 3-5. Avoid Sites with Poor Access Roads
(Source:Water Environment Federation, 1993)

To ensure that personnel can quickly locate and access monitoring sites, clear directions and site maps should be developed that diagram site access for each sampling site. An example site access map is provided as Figure 3-6. In addition, a list of special access instructions should be included within the Sampling and Analysis Plan (SAP), including information regarding required keys for locks, traffic control requirements, any necessary permits, etc.

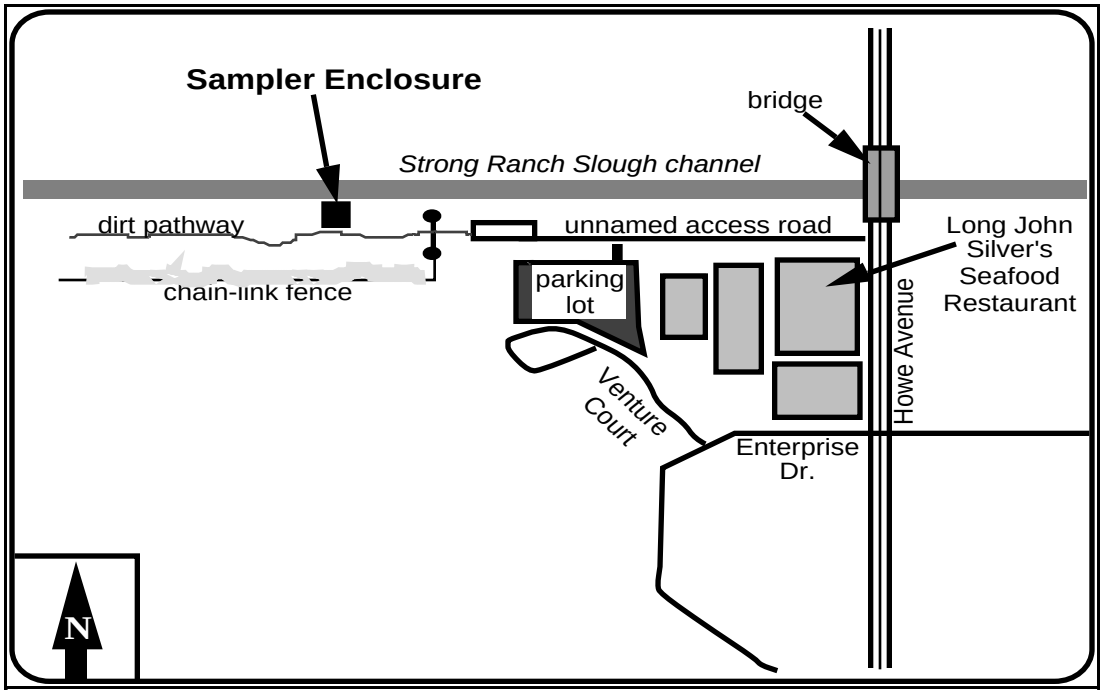

Figure 3-6. Example Site Access Map

➤ EQUIPMENT SECURITY

It is necessary to minimize the susceptibility of automated sampling and flow measurement equipment to vandalism or other possible damage. To ensure security, automated monitoring equipment should be installed in a protective enclosure that is lockable and resistant to vandalism and tampering, as discussed in ***Section 7***. Sites should be selected that have a flat, accessible area that is large enough for installation of any necessary enclosures, including fencing if necessary.

➤ FLOW MEASUREMENT CAPABILITY

Obtaining accurate flow measurements at monitoring stations is necessary to ensure representativeness of flow-weighted composite samples, to determine constituent mass loadings, and to assess the relationship between rainfall and runoff to support mathematical modeling. The hydraulic characteristics necessary to allow for accurate flow measurement include a relatively straight and uniform length of pipe or channel with no confluences (i.e., wyes or tees in the storm sewer lines) or grade changes, and the absence of backwater effects. See ***Section 5*** and ***Appendix C*** for information on flow measurement methods and flow proportional sampling, respectively.

Monitoring sites should be selected at locations where flow rate will be adequate under typical storm conditions to provide for both accurate flow measurement and automatic sample collection. This can be checked in advance by roughly calculating the runoff flow depth expected in the pipe during a storm of typical intensity for the study area.

Flow measurement stations should be located sufficiently downstream from inflows to the drainage system to achieve well-mixed conditions across the channel, and to favor the likelihood of "uniform" flow conditions. In the vicinity of a confluence, the flow sensor and sample collection inlet should be placed a minimum of five pipe diameters upstream and ten pipe diameters downstream of any confluence to minimize turbulence and ensure well-mixed flow.

Backwater effects (i.e., the effects of downstream ponding) should be avoided, especially where sampling protocols make use of depth-based flow measurement. Specifically, backwater effects will result in non-uniform flow conditions, which compromise the ability to measure flow when using depth-based methods. In addition, sampling stations in pipes, culverts, or tunnels should be located so as to avoid surcharging (pressure flow) over the normal range of precipitation expected during monitoring events.

➤ ELECTRICAL POWER AND TELEPHONE

Although not essential, direct electrical power is desired at automated monitoring stations for both reliability and maintenance. For example, if line power is available, AC power packs can be used. Use of AC power decreases routine maintenance requirements, as battery changes are not necessary. However, if AC power is not available, DC battery power can be used. See ***Section 7*** for more information.

Telephone lines can be used for remote communication with automated equipment. Telephone access provides a convenient mode of rapidly accessing information from field equipment during field activities. Cellular telephone is a possible alternative if telephone lines are not available. However, cellular phone operations should be thoroughly checked prior to any monitoring activities (e.g., ensure that there is a reliable provider in the area, and test reception).

➤ NON-CALTRANS SOURCES

Monitoring sites should be selected such that the monitored stormwater runoff originates solely within Caltrans freeway systems or facilities. Any site whose drainage area includes other land use types (e.g., commercial, residential, agricultural, etc.) should be avoided to eliminate collection of non-Caltrans flows.

➤ BMP EFFECTIVENESS

The preceding discussion of site selection considerations relates to selection of sampling locations for stormwater discharge monitoring in general terms. Studies of BMP effectiveness involve differing objectives, and the goals of BMP monitoring programs are somewhat different as well.

There are two general types of BMPs: structural and non-structural. Structural BMPs typically have well-defined boundaries and may be relatively easy to monitor. If evaluation of structural BMPs is part of the program objectives, monitoring locations should be located immediately upstream and downstream of the structure. Monitoring at these locations will enable comparison of stormwater quality influent to the BMP with stormwater quality effluent from the BMP. Such comparisons can be used to evaluate the BMP's performance in reducing constituent concentrations. The comparisons can also demonstrate the effectiveness of the BMP in reducing constituent loads, if both constituent concentrations and flow rates are measured. It is important to design such a study to include accurate flow measurement methods and sampling locations that are representative of the inflow and outflow, so as to produce credible, scientifically defensible data.

Structural BMP performance monitoring may also take place within the BMP (e.g. detention basin), where temporal changes in constituent concentrations and constituent accumulations can be examined.

When selecting sampling locations to evaluate the effectiveness of BMPs, it is important to realize the limitations that may exist, for example:

- ✔ The physical setting of the BMP may not allow the use of automated systems.
- ✔ Access to either the influent or effluent flow for manual sample collection may be restricted by the physical configuration of the device.
- ✔ Accurate flow measurement through the device may be difficult or impossible to obtain.
- ✔ Performance of the BMP may be affected by the level of maintenance required under various conditions.

Non-structural BMPs (e.g., street sweeping, catch basin cleaning, illicit discharge elimination) may be more difficult to monitor because they can be influenced by many factors that cannot be "controlled", and may not have clearly defined inlet and outlet flows. In such cases, it may be necessary to monitor the same sites before and after BMP implementation; or to monitor one set of sites where the BMP is applied, and another set of "control" sites, where the BMP is not applied. Selection of comparable representative

sites is particularly crucial for such studies. According to work sponsored by USEPA (Clusen and Spooner, 1993), it is recommended that paired sites be selected to:

- ✔ Be initially similar in physiographic and biological features, such as size, general morphology, slope, location, soils, and land cover.
- ✔ Be similar in past, present, and future human influence, except for the treatment (BMP) being tested.
- ✔ Be in a steady state at the outset of the study (i.e., no substantial changes have occurred over a number of prior years).
- ✔ Be small enough to obtain uniform treatment over the entire treatment area.
- ✔ Have a stable channel at the measurement point, especially for flow monitoring.

It is also recommended that the assignment of the control site versus the treatment site be done randomly.

➤ SITE VISIT

Each potential monitoring site should be visited to confirm the expected site characteristics and verify whether the site is suitable for the needs of the program. When possible, a visit should be conducted during or after a storm, when the discharge flow conditions can be observed. A wet-weather visit can provide valuable information regarding logistical constraints that may not be readily apparent during dry weather. However, a dry weather visit should also be conducted to observe any non-stormwater flows.

A list of criteria, specific to the program objectives and including the considerations discussed in this section, should be developed prior to visiting potential sites. These criteria should be used to produce a site visit log form, which should be filled out during each site inspection. An example of a site visit log is presented as Figure 3-7.

Criteria to be documented during a site visit may include type of site, drainage area characteristics, type of runoff, whether an appropriate sampling location exists, potential safety issues, site access, whether accurate flow measurement is achievable, and if telephone and electrical power are available.

In addition, a check list may be useful to record whether certain conditions exist at a given site, such as: tidal influences, illegal dumping, illicit connections, high groundwater table, erosion, runoff from landscaped areas, adjacent commercial farming, contributing residential runoff, or nearby industrial sites. Once these observations have been made, it

is possible to determine if the site is representative of Caltrans highways, and appropriate for the objectives of the project.

Figure 3-7. Site Visit Log*

** example log only; specific site logs should be developed based upon program objectives*

Date _____ Name of person conducting site visit _____

District _____ Location _____ Post Mile _____

TYPE OF SITE:

Roadway	☐	Construction	☐	Park-and-Ride	☐
Landscape	☐	Maintenance Yard	☐	Other	☐

*Describe:*_____

Is the drainage area 100 percent representative of site type? _____

*Describe:*_____

TYPE OF RUNOFF FROM SITE:

Curb and gutter ☐ Overland flow ☐ Other ☐

*Describe:*_____

POTENTIAL SAMPLING LOCATION (WITH ACCESS TO FLOW):

Storm drain inlet	☐	Ditch, swale	☐
Culvert	☐	BMP (e.g., retention basin)	☐
Pipe	☐	Other (describe)_____	☐

Comments: _____

ACCURATE FLOW ACHIEVABLE? ☐ yes ☐ no

*Describe:*_____

ELECTRICAL POWER AVAILABLE? ☐ yes ☐ no

TELEPHONE LINES AVAILABLE? ☐ yes ☐ no

CLEAR CELLULAR PHONE RECEPTION AT SITE? ☐ yes ☐ no

VEHICULAR SITE ACCESS? ☐ yes ☐ no

*Describe:*_____

PERSONNEL SAFETY ISSUES? ☐ yes ☐ no

(e.g., Proximity to traffic lanes, steep embankments, etc.)

*Describe:*_____

SITE CONDITIONS/OBSERVATIONS *(if yes, describe)*

Tidal influences yes ☐ no ☐

Illegal dumping yes ☐ no ☐

Illicit connections yes ☐ no ☐

High groundwater table yes ☐ no ☐

Erosion yes ☐ no ☐

Runoff from landscaped areas yes ☐ no ☐

Adjacent commercial farming yes ☐ no ☐

Contributing off-site runoff yes ☐ no ☐

Adjacent industrial sites yes ☐ no ☐

Is site representative of Caltrans Highways and/or Facilities? yes ☐ no ☐

*explain*_____

Other observations: _____